Experience for you!

“100 years of drilling, 4 decades of building machines, and still down to the earth”    Prof. Thomas Bauer

We could start by telling you about Sebastian Bauer, who founded a copper forge in the German town of Schrobenhausen some 200 years ago. We could then move on to how his workshop prospered and developed to a leading construction company for specialist foundation engineering. The story would continue to the mid 20th century, when innovation and the drive for perfection prompted Bauer to develop and build their own high-quality and high-performance machinery. And it still wouldn’t end in the 21st century, Bauer now family-run in the seventh generation and meanwhile a globally operating group with more than 100 branches and subsidiaries operating in the fields of special foundation engineering (Bauer Spezialtiefbau), in manufacturing of foundation equipment (Bauer Maschinen) and focusing on products and services in the fields of water, energy, mineral resources and environmental technology (Bauer Resources).

But we think what really matters about us and to our customers is this: We are a strong partner with face and values, we are down to earth, and we are dedicated to perfection in everything we touch.
Of the thousands of machines Bauer Maschinen has built since production started in the 1970’s with the first rotary drill rig BG 7, many of them are still in operation all over the world. State of the art technology developed end-to-end by our in-house engineers and full machine tests prior to delivery are one side of the coin. Bauer Maschinen can serve any customer need with the most comprehensive product portfolio. The other side is project-specific consulting by highly trained experts, with a focus on your special requirements.

BAUER Maritime Technologies is a new department of BAUER Maschinen GmbH. The company’s field of operation is the development and construction of special drill rigs for offshore foundations (wind farms, oil & gas) and marine exploration. Crucial factors when entering the field of maritime technologies are decades of experience in the design of foundation machinery, the full backup of our hydraulics and electronics department as well as the profound experience of Bauer’s engineers in solving extremely complex foundation problems all over the world. Our constant research of new solutions makes BAUER Maritime Technologies a valuable partner for the offshore industry.

- **Quality and experience in specialist foundation engineering**
- **Global operation – local contacts in over 70 countries**
- **Reliability in technology service**
- **Customized solutions**

![Image of Bauer Maschinen GmbH]

**BAUER Maritime Technologies**

- **1980’s**
  - Start of international equipment sales
- **1993**
  - Diamond deposit exploration with a BC cutter in water depth of 160 m (South Africa)
- **2005**
  - Drilling inside of a monopile with a Bauer Fly Drill (Barrow, UK)
- **2006**
  - Stock market launch of BAUER AG, directed by Prof. Thomas Bauer
- **2011/2012**
  - Monopile foundation in rock for tidal turbine with BSD 3000 (Orkneys, UK)
For offshore foundations there are many situations where piles cannot be driven to their full penetration. When pile refusal is reached (e.g. boulders or rock layers), when calcareous sand are not suitable for pile driving method or when noise produced by the hammering can damage the marine species, BMT is able to provide technologies for the offshore foundation engineering, based on the onshore drilling know-how. For big monopiles (up to 6 m) or for piled structures (jackets or tripods), BAUER Maschinen GmbH provides the right solutions.

### Applications

**Offshore foundations**

- Offshore wind structures

**Subsea exploration**

- Platforms for the oil & gas industry

### Systems

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Range of diameter</th>
<th>Soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>BSD (Bauer Sea Bed Drill)</td>
<td>2 - 3 m</td>
<td>Rock</td>
</tr>
<tr>
<td>Dive Drill</td>
<td>2 - 3.5 m</td>
<td>Medium dense to cemented sediments, hard cohesive soil</td>
</tr>
<tr>
<td>MIDOS</td>
<td>2 - 3 m</td>
<td>Loose non-cohesive, soft cohesive</td>
</tr>
<tr>
<td>BC cutter</td>
<td>4 - 6 m (in sections)</td>
<td>Cemented soil with boulders and rock</td>
</tr>
<tr>
<td>Fly Drill</td>
<td>1.5 - 3.5 m</td>
<td>Medium dense to cemented sediments, hard cohesive soil</td>
</tr>
</tbody>
</table>
The BSD 3000 is a reverse circulation drill with a full face roller-bit with heavy weights. It is specifically designed for drilling in rock.

**Drilling procedure**
Lower and fix the drill template at seabed level.

Instal the conductor casing inside of the template.

Lower the drill unit with rotary drive, drill pipe, heavyweights and full face roller bit into the conductor casing.

The rock is broken into pieces by the full face cutting tool.

The drill spoil is transported to the top by the air-lift technique - the air lifting pipe ends shortly above the drill rig.

All the main functions are monitored through cameras and sensors. The drill rig and the umbilicals withstand all forces caused by currents and waves. The umbilical handling system has to compensate for the unavoidable movements of the vessel.

**Main components of the BSD 3000**
1. Drill template (with legs including leveling system, weight plates and the centerpiece with casing clamp and oscillator).
2. Conductor pipe (with drilling shoe, internal brackets and plates to support the drill unit).
3. Drill unit (with rotary drive, climbing mechanism, drill pipe, heavyweights and full face roller bit).

**Additional components:**
4. The umbilicals for the supply of hydraulic oil, air, grout and signals.
5. The umbilical handling system with quick release mechanism and mooring winches.
6. The operator’s cabin with hydraulic power unit and compressors.
7. The deck storage frame for conductor pipe and drill unit.

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**Technical specifications**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating weight (approx.)</td>
<td>270 t</td>
</tr>
<tr>
<td>Drilling diameter:</td>
<td>2 - 3 m</td>
</tr>
<tr>
<td>Drilling depth:</td>
<td>11 m</td>
</tr>
<tr>
<td>Max inclination of seafloor template:</td>
<td>7 %</td>
</tr>
<tr>
<td>Torque (rotary drive) max:</td>
<td>110 kNm</td>
</tr>
<tr>
<td>Torque (oscillator) max:</td>
<td>600 kNm</td>
</tr>
<tr>
<td>Crowd force:</td>
<td>100 t</td>
</tr>
</tbody>
</table>
The Dive Drill is a rotary drilling system intended to operate from the inside of driven steel tubes to support the pile-driving method and possibly as an alternative pile installation method in hard to soft soils for many offshore foundation construction, in particular for monopiles or tripod foundations in the diameter range up to 3.5 m.

The Dive Drill is used to clean out the soil plug inside of the casing, which is an effective means to reduce driving resistance. It can also be used to predrill in hard strata that impede the further driving of the pile and also for milling glacial erratics that might be found, which would obstruct proper pile installation.

System and work description
The Dive Drill is mounted on a specially modified crawler crane (preferably BAUER MC 128), which contains all controls, power and umbilical winches to operate the dive drill safely and efficiently.

It is lowered into the casing and clamps itself to the sidewall of the casing.

There are two clamping systems for the ablation of the torque and thrust forces in the casing: one is located at the torque unit and the second one at the drill head.

The drilling torque is generated in the rotary drive and transmitted to the drill head with a telescoping drill string.

A specially designed drilling tool loosens the soil/rock. The dissolved cuttings are fed to the cone crusher by a screw flight and hydraulic support, where larger cuttings are broken down. In the mixing chamber, located above the cone crusher, the cuttings are mixed with seawater and pumped to the surface.

After drilling of one feed length, the clamp at the drill unit is fixed and the clamp at the torque unit is released and the drive unit is topped by the feed cylinder.

The drill process continues by clamping the torque unit and releasing the drill head unit. Thus a continuous vertical advancement of the Dive Drill is reached inside of the casing until it reaches the desired depth.

Dive Drill – Advantages:
- Easy and fast switching from pile driving to relief drilling.
- Direct installation into the casing regardless of the position of the top of the casing (above or below the water table).
- Manifold teeth configurations allow drilling in various soil conditions.

Technical specifications

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>Operating weight:</td>
<td>35 t</td>
</tr>
<tr>
<td>Drilling diameter:</td>
<td>1.75 - 3.5 m</td>
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<tr>
<td>Max. water depth:</td>
<td>250 m</td>
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<tr>
<td>Torque (rotary drive) max:</td>
<td>275 kNm</td>
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<tr>
<td>Torque (second rotary drive):</td>
<td>275 kNm optional</td>
</tr>
<tr>
<td>Feed force:</td>
<td>1,000 kN</td>
</tr>
<tr>
<td>Pump capacity:</td>
<td>450 m³/h</td>
</tr>
</tbody>
</table>
A Bauer innovation for seabed drilling is the MIDOS Pile - Mixed Drilled Offshore Steel Pile. This piling system combines the experience and know-how of Bauer for seabed drilling and soil mixing techniques. The MIDOS-Pile is a piling solution for offshore foundations, offering reliable foundation piles for jacket structures with negligible noise emissions at competitive costs. Wherever rock drilling is not required, the MIDOS system can be used.

The structural element of the MIDOS Pile is a steel casing; the dimensions are determined by design calculations, usually 2 m to 3 m in diameter and lengths of 30 m to 45 m. The casing is positioned in the satellites of the Bauer modular template. A starter with a diameter of 30 to 40 cm larger than the casing diameter is mounted at the toe of the casing.

One or two rotary drives are clamped inside of the top area of the casing. A mixing tool is positioned at the bottom end of a vertical drive shaft and rotated by the top rotary drive.

Specially designed cement slurry exits the mixing tool, so that the loosened soil is immediately mixed with this slurry to a soil-cement-mixture. When reaching the final depth, the rotary drives with the shaft and the mixing tool are extracted, while the casing and the starter piece remain in place.

The final strength of the soil/cement mixture depends on the prevailing soil conditions and the amount of cement slurry.

**Technical specifications**

- Operating weight (approx.): 17 - 23 t
- Min. casing diameter: 1,850 mm
- Torque: 300 - 500 kNm
- Height of mixing chamber: 3,200 mm
- Variable length of drill rods
The trench cutter is an excavating machine which is usually used in the foundation engineering for constructing underground walls. It operates on the principles of reverse circulation. It is made up of a heavy steel frame with two gear boxes at the bottom of the frame. Cutting wheel drums fitted with a series of teeth are fixed to the gearboxes; they rotate in opposite directions, break up the soil and mix it with the bentonite suspension. As the cutter penetrates, soil, rock and bentonite slurry are conveyed towards the openings of the suction box, from where they are pumped by a centrifugal pump through the slurry pipe incorporated in the cutter’s frame, to a desanding plant on the surface. There, solid soil and rock particles are separated from drilling fluid which is pumped back into the trench or for storage and later reuse.

They would impede the proper pile installation. The pile would be driven to refusal and that would prevent the reaching of the design depth. The BC trench cutter might be used in order to mill the rock. The torque output of the cutter wheels in combination with the weight of the cutter is sufficient to cut into any type of soil, to crush cobbles, small boulders or rock. From a jack-up barge, the trench cutter would be immersed in the water by a crane (i.e. MC 128).

The use of trench cutter Technology for removing obstacles inside of monopiles
During the installation process of large monopiles it is possible to encounter erratics of big dimension (volume of at least one cubic metre) in glacial submarine sediments.

The cutter is fixed in a special guide frame. There it can slide in x-direction, while the frame system can be rotated ±90° inside of the monopile. Thus, erratics or boulders, which impede pile driving, can be cut and milled at any position inside of the circular borehole. The weight of the guide frame is about 30 tons.

Technical specifications BC 40
- Gearbox 2 x BCF10
- Torque max. 100 kNm
- Speed of rotation 0 - 25 rpm
- Cutter length 2,800 - 3,200 mm
- Cutter width 800 - 1,800 mm
- Overall height 12.6 m
- Max delivery rate mud pump 450 m³/h
- Weight 32.5 - 41 t
Circular trench cutter technology (CTC)
The CTC technology is a new option of the trench cutter technology for offshore monopile installation. The idea is to create an annular ring cut where the steel tubular structure is inserted and possibly fixed by grouting. The CTC arrangement and the template is deployed on the seabed from a jackup barge.

A central pilot trench is excavated with a depth of approximately 2.5 m. The spike 1 (or 2) is inserted in the pilot trench and acts as pivot for the rotation of the CTC. When the first trench is finished, the whole template is rotated around the the spike in the pilot trench and the next trench is cut. This process is repeated until a continuous annular ring is excavated.

After installing the monopile, the cutter together with the template is removed. The weight of the CTC frame is about 30 tons. The system allows the construction of circular or ellipsoidal rings.
The FLY DRILL method is a new concept for bored piling. The drilling unit with rotary head, kelly bar and drilling tool is suspended by the hoist rope of the base carrier crane. The hydraulic power for the drill unit is provided from the base crane (e.g. BAUER MC crawler cranes) or from an external powerpack.

- The main components of the drill, in particular the rotary drive and the kelly bar originate from the well established BAUER BG series.
- The Fly Drill system can be operated with a lockable three-fold kelly bar or with a four-fold friction Kelly bar.
- The unit can be rigged-up without external assistance.
- When working in mixed soil conditions, where soil is underlain by rock, the FLY DRILL can also be combined with full-face RCD systems for rock drilling.

Main features of the FLY DRILL:
- The suspended drill, free from base machine, has high versatility when working in different ground levels and with varying working radius (e.g. piles in slopes). The FLY DRILL system is ideally suitable for shallow offshore piling from a floating barge.
- It is a highly versatile ‘mobile’ pile-top drilling system for applications in kelly mode in all types of soil and weak rock. The key advantage of the system is the ability to operate pile driving equipment and drilling equipment in an alternating sequence whenever driving would be stopped by refusal before reaching the terminated depth.

The drill head is fixed on the casing with a hydraulically operated clamping system during the drilling operation. When emptying the drilling tool, the clamp cylinders are opened and the complete unit is swung sideways.

**Reference example**
On a large offshore wind farm in UK coastal waters in the East Irish Sea, 30 wind towers had to be installed, resting on monopiles. The tubular steel piles have a diameter of 4,750 mm and are up to 61 m long with a penetration depth from 30 – 40 m below seabed level.

The geology of the area beneath the wind farm site comprises variable sequences of medium dense to very dense sands, firm to stiff and very stiff to hard clays and weathered mudstone, siltstone and sandstone. Whilst these conditions are generally suitable for pile driving with ultra-heavy piling hammers, formations such as completely weathered mudstone and weak to moderately weak siltstone/sandstone at elevations above the toe levels of the monopiles have the potential to result in refusal of monopiles during driving.

The majority of monopiles installed could be driven to their terminated penetration depth. Nine piles refused further driving and thus required drilling to facilitate full penetration by subsequent driving.

The aim of drilling out the core from inside monopiles that refused above their final elevations is to reduce both frictional and end resistance. By drilling the soil material out from inside the tubular steel pile, the skin friction acting on the internal surface of the monopile is eliminated over the drilled out length.

**Technical specifications BFD 1500 – BFD 3500**

<table>
<thead>
<tr>
<th>Torque</th>
<th>kNm</th>
<th>147 - 360</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stroke crowd cylinder</td>
<td>mm</td>
<td>1,000 - 1,500</td>
</tr>
<tr>
<td>Crowd force (push/pull)</td>
<td>kN</td>
<td>2 x 70 - 2 x 120</td>
</tr>
<tr>
<td>Drilling diameter</td>
<td>mm</td>
<td>1,000 - 3,500</td>
</tr>
<tr>
<td>Drilling depth (depends on base carrier)</td>
<td>m</td>
<td>20 - 60</td>
</tr>
</tbody>
</table>

* other diameters on request
The original drilling system MeBo for scientific investigations was developed by the MARUM Center for Marine Environmental Sciences at the University of Bremen. It includes, besides the drill rig, the complete system such as operator’s cabin, launch and recovery system and umbilical winch. Based on experiences with the first MeBo (drilling depth 80 m), MARUM and BAUER Maschinen GmbH are currently building a second drilling system for drilling depths of up to 200 m (MeBo 200). BAUER is focusing on the drill rig and on the launch and recovery system in this project. The previous generation of the MeBo 200 was tested successfully in July/August 2005 in deep water at the continental slope off Morocco.

The MeBo sea floor drill rig is a portable rig which is remotely operated from a vessel. It can be deployed in water depths up to 4,000 m for conducting core drilling down to 200 meter below sea floor.

Main applications
Soil sampling from soft sediments to hard rock.

Geotechnical exploration for offshore foundation installation.

Searching of minerals in marine environment (e.g. diamonds).

Drilling for natural resources offshore (e.g. gas or oil).

Exploration of marine sulfide deposits.

The possibility of drilling tests for gas hydrate are currently studied.

Work sequence
1) Remote controlled from a vessel, the MeBo is deployed to the sea bed, using a steel armored umbilical to depths up to 4,000 m.

2) Four legs are extended before landing to increase the stability of the rig and leveling due to possible unevenness of the sea bed.

3) The mast with the feeding system and the power swivel forms the central part of the drill rig. It is mounted on a guide carriage that moves up and down the mast with a maximum push force of 5 tons.

4) A water pump provides sea water for flushing the drill string, for cooling of the drill bit, and for drill cuttings removal. The system utilizes rotary core barrels with diamond or tungsten carbide bits.

5) The MeBo stores drilling rods and core barrels on two rotating magazines that may be loaded with a mixture of tools as required for a specific task. With a storing capacity for core barrels with a length of 4.7 m, the MeBo 200 is capable of drilling down to 200 m into the sea floor, recovering cores with 54 – 63 mm diameter.

The MeBo might also be equipped with a rotary vibratory drill which is capable of high drilling speeds as well as accomplishing tasks, such as continuous coring that cannot be carried out by any other equipment. Sea bed drill rigs are not affected by any ship movements due to wind or waves. Since they operate from a stable platform on the sea bed, optimal control of drill-bit pressure can be achieved, which is prerequisite for optimal core quality.

Technical specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating weight (in air):</td>
<td>10 t</td>
</tr>
<tr>
<td>Coring diameter:</td>
<td>54 - 101 mm</td>
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<tr>
<td>Drilling depth:</td>
<td>200 m</td>
</tr>
<tr>
<td>Max. water depth:</td>
<td>4,000 m</td>
</tr>
<tr>
<td>Torque:</td>
<td>1,700 Nm@180 rpm</td>
</tr>
<tr>
<td></td>
<td>450 Nm@450 rpm</td>
</tr>
<tr>
<td>Feed force:</td>
<td>50 kN</td>
</tr>
<tr>
<td>Pulling force:</td>
<td>100 kN</td>
</tr>
<tr>
<td>Pump capacity (max.):</td>
<td>160 l/min.</td>
</tr>
<tr>
<td>Pump pressure (max.):</td>
<td>60 bar</td>
</tr>
<tr>
<td>Tool length:</td>
<td>4.7 m</td>
</tr>
</tbody>
</table>
Design developments and process improvements may require the specification and materials to be updated and changed without prior notice or liability. Illustrations may include optional equipment and not show all possible configurations. These and the technical data are provided as indicative information only, with any errors and misprints reserved.